SYSTRON DONNER CORPORATION

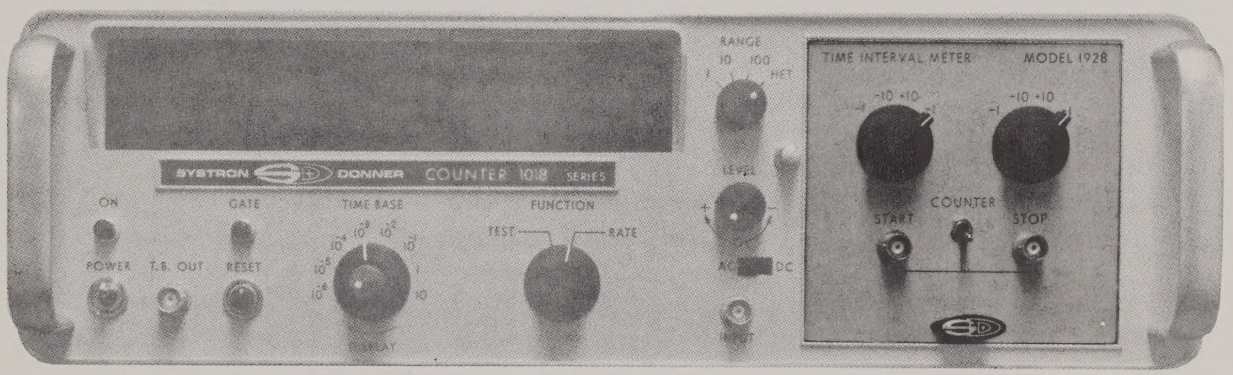
[redacted]

Instruction Manual

ELECTRONIC AND INERTIAL INSTRUMENTATION FOR MEASUREMENT, SIMULATION, CONTROL

SD 1928
10 ns Time Interval Meter
Plug-In

Modified 9-5-68
Don Stiller



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CHAPTER 1
GENERAL INFORMATION

1.1 GENERAL DESCRIPTION

The SD 1928 Time Interval Meter Plug-In converts either the SD 1018 or SD 1038 Counter into a time-interval measuring system with a resolution of 10 nanoseconds. Separate START and STOP channels are provided and both have controls for selecting attenuation ratio and polarity. The channels may be paralleled for measuring the time interval between events occuring in a single signal line, but this mode of operation requires an external impedance-matching network. When the SD 1928 COUNTER- (TIM) switch is placed in the COUNTER position, the counter may be used in its normal counter/timer mode.

The counter provides the time-interval readout directly in microseconds without annunciation. Figure 1-1 shows the SD 1928 installed in its parent counter.

Figure 1-1. SD 1928 installed in an SD 1018.

1.2 SPECIFICATIONS

Range: 30ns to 1.0s (SD 1038); 30ns to 100ms (SD 1018).
Resolution: 10ns.
Accuracy: ±10ns ±time base stability.
Time Base Stability: Derived from parent counter or external standard.
Minimum Trigger Pulse Amplitude: 1.0V peak with 0.5V/ns rise (0.01V/ns rise at reduced accuracy).
Minimum Trigger Pulse Width: 20ns for pulse interval measurement; input time constant approximately 300ns.
Overload: 10V peak, 50% duty cycle (X1 and X10); 50V peak, 10% duty cycle (X10 only).
Trigger Polarity: Positive or negative, switch selectable.
Attenuation Ratio: X1 or X10, switch selectable.
Registration: Parent counter display with decimal point positioned for least significant digit of 0.01ns.
Accessories Furnished: Two 6-foot coaxial cables.

1.3 EQUIPMENT SUPPLIED

Equipment and publications normally supplied are listed in Table 1-1:

Qty per Equipment	Name	Designation	Weight (lbs)
1	Time Interval Meter	SD 1928	2.5 7.0 (Shipping)
2	Instruction Manual		
2	Coaxial Cable, 6 foot	RG58 ( )/U	

Table 1-1 Equipment Supplied

1.4 EQUIPMENT REQUIRED BUT NOT SUPPLIED

A list of equipment and publications required but not supplied for the operation, troubleshooting and calibration of the SD 1928 is shown in Table 1-2:

Qty per Equipment	Name	Designation	Required Use
1	Electronic Counter	SD 1038 or SD 1018	Provide operating voltages and display
1	Instruction Manual for SD 1038 or SD 1018		Provide operating instructions for counter
	Transformer, matched tee	Tektronix Model 017-012 or equivalent	Impedance matching when START-STOP channels are paralleled
	Calibrated (30ns) Delay Line	Length of RG-58 ( )/U Coaxial cable	Check TIM specifications and testing
1	Pulse Generator	Datapulse Model 111 or equivalent	Troubleshooting and calibration
1	Oscilloscope	Tektronix Model 581A with Model 82 or 86 plug-in or equivalent	Troubleshooting and calibration

1.5 PREPARATION FOR RESHIPMENT

Should reshipment become necessary, contact the nearest Systron-Donner field office for shipping instructions. If possible, use the original packaging materials or repack in accordance with MIL-P-116 and MIL-E-17555E. Systron-Donner field offices can provide materials similar to those used for original factory packaging. All correspondence should refer to the full nomenclature and serial number of the instrument involved.

CHAPTER 2
INSTALLATION

2.1 INSTALLATION REQUIREMENTS

The SD 1928 is designed for use only with the SD 1018 and SD 1038 counters. Do not attempt to install in and operate with any other SD counter.

2.2 INSPECTION AND ADJUSTMENT

As soon as the instrument is received, verify that it is intact as ordered. Check for loose or broken control knobs, bent or broken connectors, and dents or scratches on the panel surfaces. If damage of any nature is found, refer to the Warranty (inside back cover) and to Paragraph 1.7 for repackaging and shipping instructions.

An overall functional section test should be performed as soon as the instrument is received, following a procedure similar to that in Table 4-2 of this manual. All internal adjustments are initially made at the factory; the instrument is ready for use as received. Should the instrument fail to function properly or fail to meet specifications, contact your Systron-Donner Representative.

CHAPTER 3
OPERATION

3.1 FUNCTIONAL OPERATION

The SD 1928 TIM converts either the SD 1018 or SD 1038 counter into a time-interval measuring system capable of determining time between events in single or separate signal lines with a resolution of 10 nanoseconds. The SD 1928 accepts a 10MHz signal from the internal standard of the counter, multiplies it to 100MHz and applies this frequency to the decimal counting circuitry of the counter. A start pulse, applied to the START input jack of the SD 1928 opens the electronic gate in the plug-in. The stop pulse closes the gate.

The instrument receives its DC operating voltages from the counter, and also receives a 1kHz signal from the counter's time-base circuit. This signal is used in conjunction with the START/STOP pulses to control the counter gate. Because the standard frequency counted is 10^8Hz derived from the time-base oscillator of the counter, the resolution of 10^{-8} seconds is achieved with an accuracy of ±1 count at 10^8Hz ± time-base stability. Readout is obtained directly in microseconds with the decimal point positioned for the least significant digit of 0.01 microseconds.

Signal and power paths between the SD 1928 TIM and its counter are illustrated in Figure 3-1:

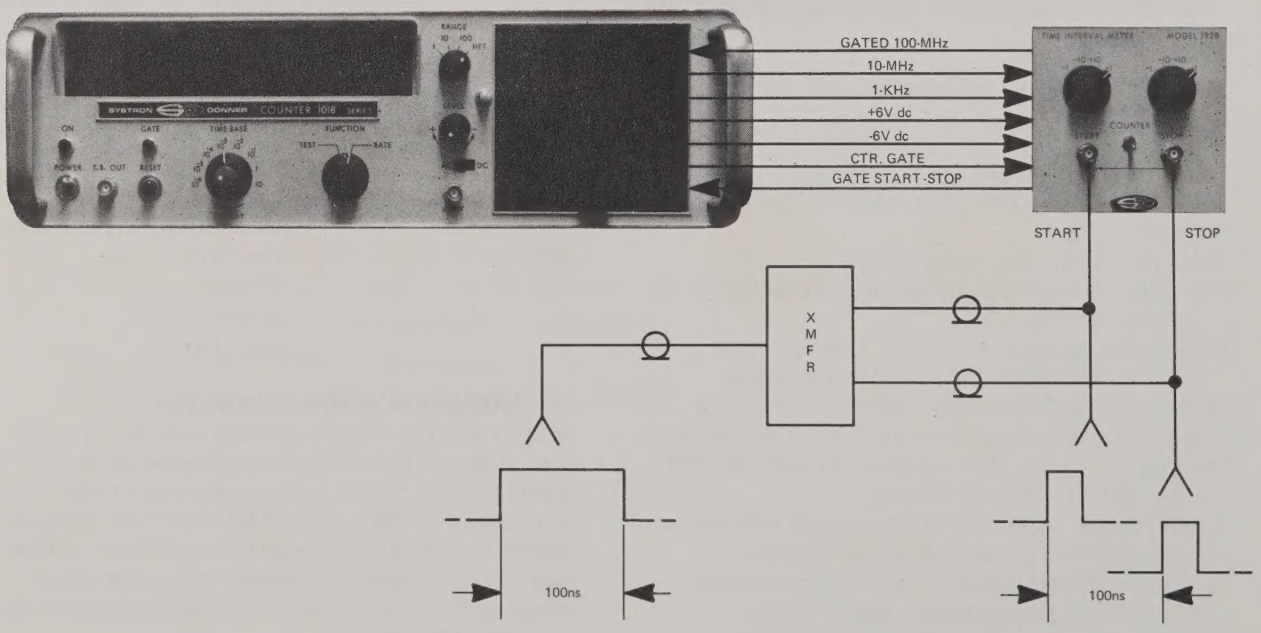


Figure 3-1 Signal and power paths between the SD 1928 TIM and its counter.

3.2 PREPARATION FOR USE

3.2.1 INSTALLATION OF PLUG-IN

1) Make sure the counter's POWER switch is OFF.
2) Remove the plug-in or blank panel installed in the counter by turning the locking knob located at the left of the plug-in receptacle at least two turns counter-clockwise. Pull the plug-in out by its handle. Generally, a firm pull is required to unseat the connectors.
3) Check to see that the printed-circuit boards in the SD 1928 are firmly seated, then insert the plug-in into the receptacle, pushing it until it is flush with the counter's front panel. A firm push is usually necessary to properly seat the connector at the rear of the plug-in.
4) Lock the plug-in in place by turning the locking knob clockwise until tight. Check by giving the plug-in handle a firm pull. If it is not locked in, back off on the locking knob and re-tighten.

3.2.2 REMOVAL OF THE SD 1928

Follow the same procedure as above. Make sure that either a blank panel or another interchangeable plug-in is re-installed in the counter.

3.3 DESCRIPTION OF CONTROLS (See Figure 3-2)

A. COUNTER-(TIM) switch, S3. Provides normal operation for counter in the COUNTER position. In the (TIM) position it:
   1) Enables the TIM circuits by switching in ±6V from the counter.
   2) Opens MU annunciator circuit in counter and illuminates decimal point between second and third digit from right on counter readout.
   3) Switches counter time-base control from counter to TIM.

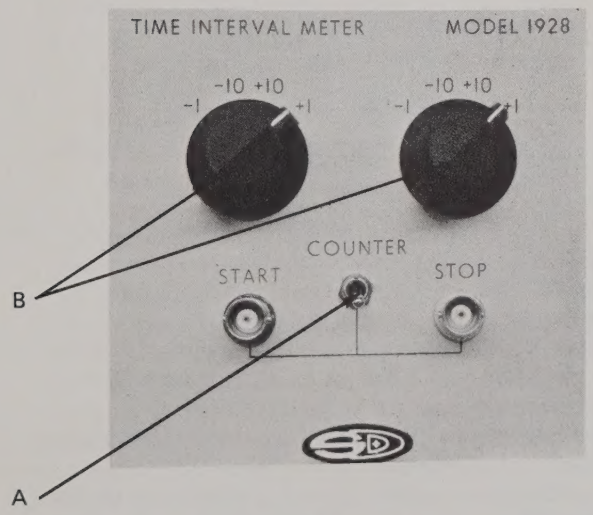


Figure 3-2 Location of Front-Panel Controls

B. START and STOP signal attenuation and polarity select (S1 and S2).
   1) Provides triggering in respective channel on either positive or negative slope of input waveform.
   2) Selects either X1 or X10 attenuation of input voltage applied to respective channel.

3.4 SEQUENCE OF OPERATION

The sequence of operation of the SD 1928 consists of performing initial test functions on both the counter and TIM, then interconnecting the instrument in one of two basic modes to perform time-interval measurement. This is illustrated in Figures 3-3 and 3-4, and Table 3-1:

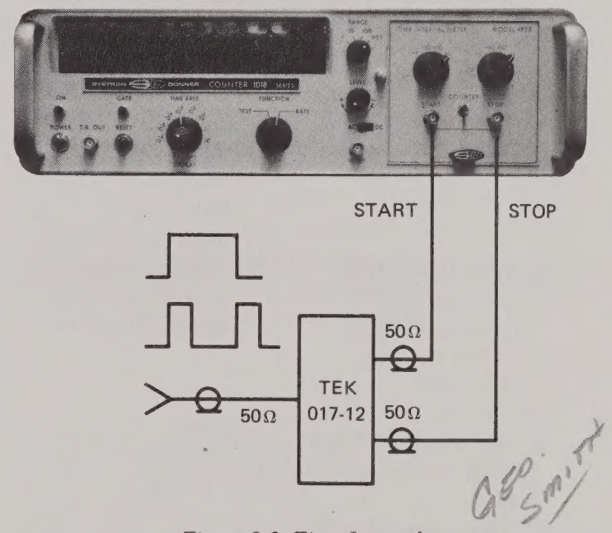


Figure 3-3 Time Interval Measurement in a single signal-line.

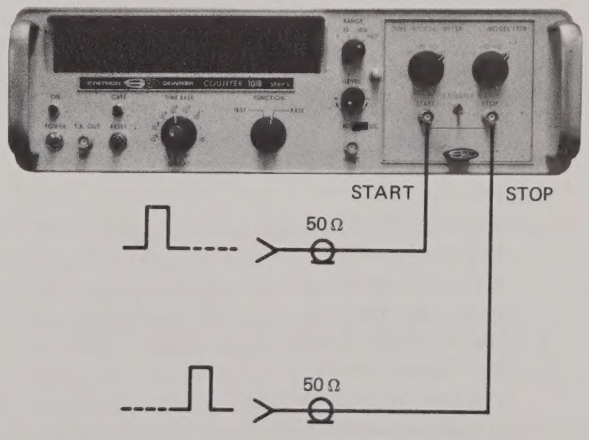


Figure 3-4 Time Interval Measurement in separate Signal Lines

Table 3-1 SD 1928 Operating Procedures

Step	Action	Indication
1	Parent Counter Test	
	a) Set COUNTER-(TIM) switch to COUNTER position.	
	b) Place FUNCTION switch in TEST position.	
	c) Turn DISPLAY control fully counter-clockwise.	
	d) On counter rear panel, set INTERNAL-EXTERNAL switch on INTERNAL.	
	e) Turn the TIME BASE switch to "1" (SD 1038) or "10^{-1}" (SD 1018).	
	f) Turn counter POWER switch ON.	1) ON lamp illuminates. 2) Annunciator indicates KC 3) Display indicates 10000.000 (SD 1038) or 1000.00 (SD 1018)
	g) Place FUNCTION switch in RATE C position (SD 1038) or RATE position (SD 1018)	4) Counter display indicates all zeros, either counter
2	SD 1928 Test	
	a) Set both START and STOP channel switches to ±10.	
	b) Set counter RANGE switch to HET.	
	c) Set COUNTER-(TIM) switch to (TIM).	5) Counter GATE lamp lights. 6) Decimal point appears between second and third digits from left.
	d) The SD 1928 is now ready for use.	
3	Time Interval Measurement with Parallel Input	
	a) Set START/STOP channel switches to attenuation factor and polarity desired. Polarities must be same for both channels for time-interval measurement; opposite for pulse-width measurement. Use X10 attenuation factor for input levels above 10V peak.	

WARNING: DO NOT PERMIT DC LEVELS TO EXCEED 5V AT EITHER START OR STOP CHANNEL INPUT REGARDLESS OF ATTENUATION FACTOR. OBSERVE 10V PEAK LIMITATION AT 50% DUTY CYCLE.

Step	Action	Indication
	b) Connect equipment as shown in Figure 3-3.	1) Counter display indicates time interval in microseconds.
4	Time Interval Measurement with Separate Signal Lines	
	a) Set START/STOP switches to attenuation and polarity desired.	
	b) Connect equipment as shown in Figure 3-4.	1) Counter display indicates time interval in microseconds.

3.5 OPERATOR'S MAINTENANCE

No special operational or preventive maintenance procedures are required for the SD 1928. When the instrument is not in use and outside the parent counter, it should be stored inside an appropriate container to prevent damage to exposed hardware and circuitry.

3.6 TECHNIQUES OF TIME INTERVAL MEASUREMENT WITH THE SD 1928

3.6.1 PRINCIPLES OF TIME INTERVAL MEASUREMENT

The basic principles of time interval measurement with digital counters are illustrated in Figure 3-5. The basic idea of this arrangement is to provide an accurate measurement of the time difference between a selected point on the signal waveform at INPUT A and a point on the signal waveform at INPUT B and to display this time difference as a direct digital readout. In this manner, convenient and highly precise measurements of pulse width, pulse spacing and the time between electrical events may be made.

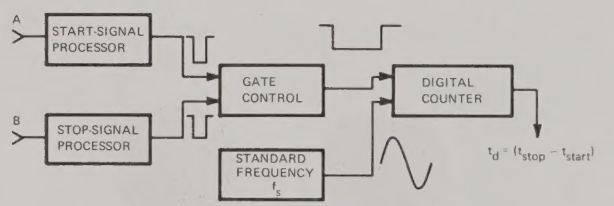


Figure 3-5 Basic TIM Scheme

The signal processor circuits are used to shape the input signal for triggering and gate control, and to select the polarity and level at which triggering occurs. The gate control opens the counter gate during the interval between selected START and STOP pulses, allowing the 100MHz frequency to be counted and displayed during this interval. The readout thus indicates time interval with a resolution of $1/f_s$, where f_s is the standard frequency counted.

Depending on the accuracy desired, this frequency may be derived from the internal standard oscillator of the counter or from an external source.

3.6.2 RESOLUTION AND ACCURACY

As pointed out above, the resolution of time-interval measurement is determined by the standard frequency counted. In the SD 1928, this frequency is 100MHz providing a resolution of 10 nanoseconds. Accuracy of time-interval measurement depends on the following factors: stability of the standard frequency, gating error, trigger error and loading error.

3.6.3 STABILITY OF STANDARD FREQUENCY COUNTED

The standard frequency counted is derived from the parent counter's internal oscillator. Three different internal oscillators are available at the time of purchase. Stability of the 100MHz counting frequency translated from the stability of the various internal oscillators is given in Table 3-2.

	Standard Oscillator	High Stability Oscillator (B Option)	Super-High Stability Oscillator (B4 Option)
Aging Rate	3ns/24 hrs	1ns/24 hrs	0.5ns/24 hrs
Warm-up time to reach A/R	within 72 hrs	within 30 hrs	Same as B option
After 60 days continuous operation	3ns/24 hrs	0.2ns/24 hrs	Same as B option
Short-term average over 1 second	0.2ns rms	0.1ns rms	Same as B option
Variation with temp. -20° C to +25° C	±9ns/° C (±0.2ns avg)	Same as Standard	Same as Standard
±10% change in line voltage	±0.5ns	Same as Standard	Same as Standard
Long-term Aging Rate	20ns/7 days	30ns/30 days	15ns/30 days

Table 3-2 Specifications of 100MHz Standard Frequency

To insure the highest stability of the standard frequency, the following considerations apply:

1) Maintain the parent counter plugged-in and turned-on to keep the internal standard oscillator continuously energized.
2) If the counter has been turned off for more than one hour, allow sufficient warm-up time to reach aging rate.
3) Maintain constant environmental conditions.
4) Monitor line voltage.
5) Employ a higher stability oscillator.
6) Calibrate standard oscillator more frequently.

3.6.4 GATING ERROR

Gating error can produce a ±1 count error in the least significant digit. All types of digital readout instruments are subject to this irreducible ±1 count gating error. The error is possible because the signal counted is not synchronized with the pulses which initiate and stop the counter gate. Figure 3-6 illustrates this error.

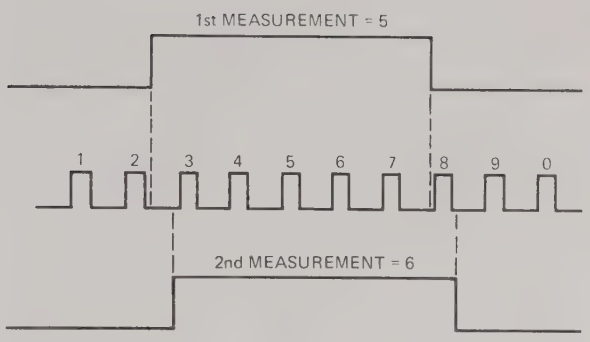


Figure 3-6 Gating Uncertainty

Increasing the time interval measured decreases the percentage of error due to this uncertainty.

3.6.5 TRIGGER ERROR

Trigger error can be caused by two things; noise riding on the input signal, and input amplifier trigger level variations. The effect of noise on trigger error is illustrated in Figure 3-7. The total signal may be considered as an ideal noise-free signal with a superimposed noise signal. As seen in Figure 3-7, the noise may cause either premature or delayed triggering thus either lengthening or shortening the time interval measurement "T" by an amount "t". This error can be reduced by improving the signal-to-noise ratio.

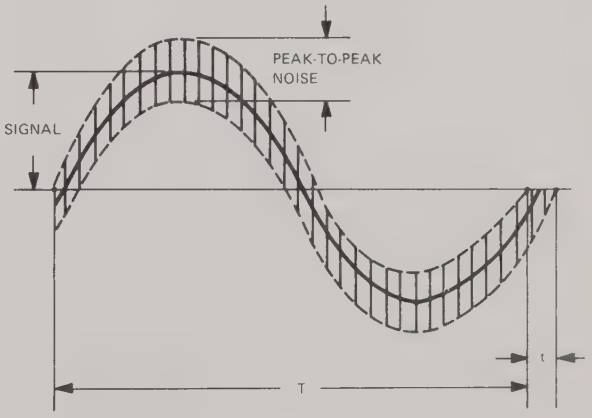


Figure 3-7 Trigger error due to noise.

While not particularly significant in longer time-interval measurements, the small variation in the trip-point level of the shaping amplifier must be considered in high-resolution systems. Figure 3-9 illustrates the trigger ambiguity with decrease in signal waveform slope. With the SD 1928, a minimum input slope of 0.5V/ns is required to maintain specified accuracy. Input slopes to 0.01V/ns with sufficient amplitude, will trigger the instrument but with reduced accuracy. With this slope, a 0.1V variation in trip-point will result in an ambiguity of 10ns. Because of the L/R circuit used at the input of the START and STOP channels, sensitivity is also dependent upon signal slope.

This input differentiator has an output voltage dependent upon rate-or-rise of input voltage and for the circuit constants involved, the rated sensitivity of 1V peak is achieved only with a 0.5V/ns rise or faster.

3.6.6 LOADING ERROR

This type of error occurs when the impedance presented by the time-interval meter to the signal source is of such magnitude that it will modify the signal source impedance to a point where a phase or amplitude shift of the signal occurs. To avoid this type of error, proper matching of the 50Ω inputs of the SD 1928 must be effected for all measurements.

3.6.7 LIMITATIONS ON PULSE WIDTH AND PULSE INTERVAL MEASUREMENTS

The minimum pulse interval that may be measured with the SD 1928 is set by the minimum pulse width requirements for the START/STOP channels and an additional delay required to enable the STOP channel after the START pulse has been received. This is due to the J-K flip-flop circuit used in the gating circuits of the SD 1928, and sets the minimum pulse-interval measurement at 30ns. Figure 3-8 illustrates the enabling time for the START and STOP channels.

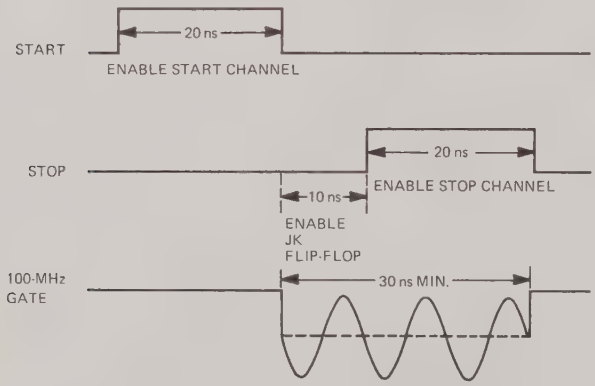


Figure 3-8 Minimum Pulse Interval Measurement

Pulse width measurements are accomplished by differentiating the input pulse and then using the leading and trailing spikes to trigger the START and STOP channels respectively. The input L/R circuit time constant limits input pulse width to ≥300ns for reliable triggering of the STOP channel at 1 volt. Thus, as shown in Figure 3-10, a wide pulse gives almost full differentiation while a narrow pulse results in a marginal amplitude of the trailing spike.

External differentiation may be used to measure narrow pulse widths which would normally be impossible to measure due to the input time constant.

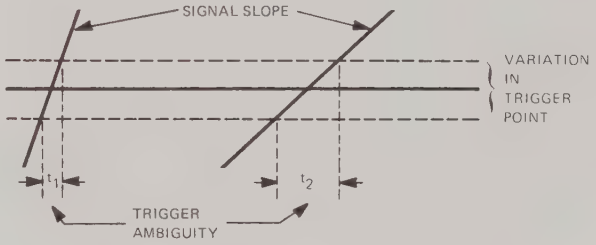


Figure 3-9 Result of decrease in signal slope on trigger ambiguity.

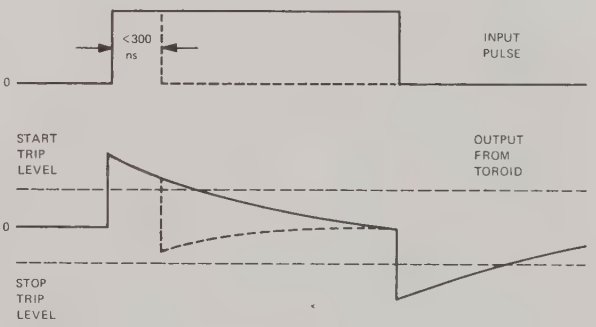


Figure 3-10 Minimum Pulse Width Measurement.

CHAPTER 4
TROUBLESHOOTING

4.1 OVERALL FUNCTIONAL DESCRIPTION

The functional block diagram of the SD 1928 is illustrated in Figure 4-1. The individual assemblies with the exception of the input switches are constructed on printed-circuit boards which may be removed for purposes of adjustment, troubleshooting and replacement of parts. The following are the functional sections of the SD 1928:

a) Input Switch Assembly, S25124. This assembly is used in both the START and STOP channels and provides X1 and X10 attenuation factors, polarity selection and differentiation of the input signal, with the output connected to the START/STOP shaper assembly.

b) START/STOP Shaper, S23694. This assembly sets the triggering level and provides rectangular start/stop pulses for the Gate and Logic assembly. Identical Schmitt-trigger circuits are used.

c) Gate and Logic Assembly, S23709. This assembly generates the counter gate start/stop signals and provides a gated 100MHz frequency to the counter input during the time interval between start and stop pulses from the shaper assembly.

d) 100MHz Multiplier Assembly, S23684. This assembly multiplies the 10MHz from the counter standard into the 100MHz counting frequency.

4.2 OVERALL TROUBLESHOOTING

The SD 1928 TIM is a rugged, all solid-state instrument and should provide long, trouble-free service. Apparent malfunction is sometimes due to the operator being unfamiliar with the instrument. It is wise to double-check instrument connections and to review specifications to make sure operation is not being attempted beyond the capability of the instrument. The most likely cause of actual malfunction is burn-out of the input switch assembly due to accidental overload from external circuitry. If overload is suspected, a visual and resistance check of the switch assembly should be made.

The DC resistance at either the START or STOP input BNC connectors to ground should be 51Ω ±5% in the -1 and +1 positions, and 49Ω +5% in the -10 and +10 positions of the attenuator switch.

For other malfunctions, the chart in Table 4-2 will be useful for overall symptom recognition and fault localization. Troubleshooting procedures for individual assemblies are given in subsequent paragraphs of this chapter. The equipment required for troubleshooting is listed in Table 4-1.

TYPE	MODEL
Electronic Counter	SD 1018 or SD 1038
Oscilloscope	Tektronix 581A with Model 82 or 86 Plug-In, or equivalent
Pulse Generator	Datapulse Model 111 or equivalent
Transformer, Matched Tee	Tektronix Model 017-012 or equivalent
Delay line, 30ns	Calibrated length of RG-58 ( )/U
Multimeter	Simpson Model 260 or equivalent

Table 4-1 Equipment Required for Troubleshooting

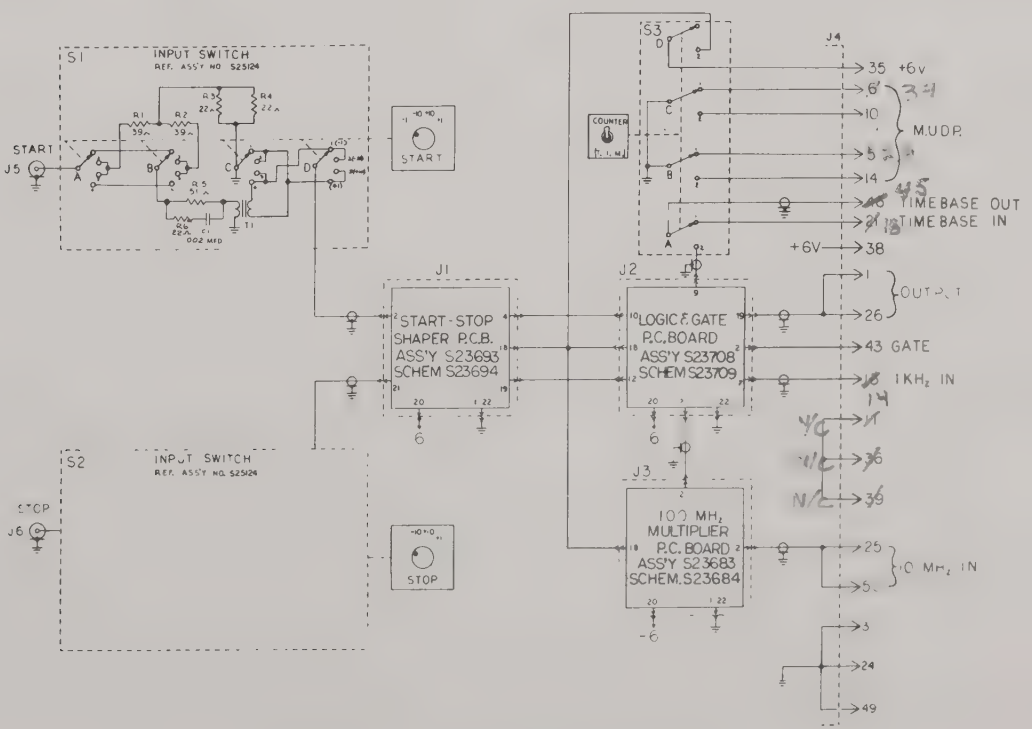


Figure 4-1 SD 1928 Functional Block Diagram

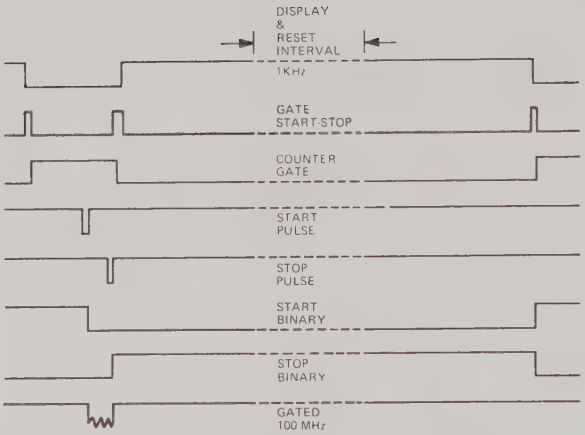


Figure 4-2 SD 1928 Timing Diagram

Table 4-2 Overall Troubleshooting

Step	Action	Results	Next Step
1	Test Parent Counter a) Set COUNTER-(TIM) switch on SD 1928 to COUNTER. b) Set counter FUNCTION switch to TEST. c) Turn counter DISPLAY control fully CCW d) Set counter rear-panel STORAGE switch to ON and INT-EXT switch to INTERNAL. e) Set counter TIME-BASE switch to "1" (SD 1038) or 10^{-1} (SD 1018) f) Turn counter POWER switch ON.	1) ON lamp lights, annunciator indicates "kc" and display reads 10000.000 (SD 1038) or 10000.00 (SD 1018). 2) Fault indication	3 2
2	Refer to appropriate counter instruction manual for servicing instructions.		
3	Test SD 1928 Gate and Logic a) Set counter FUNCTION switch to RATE C (SD 1038) or RATE (SD 1018). b) Set SD 1928 START and STOP channel switches to ±10 position. c) Set counter RANGE switch to HET position. d) Set SD 1928 COUNTER-(TIM) switch to (TIM) position.	1) Counter GATE lamp lights and decimal point appears between 2nd and 3rd digits from left on counter display. 2) Gate lamp does not light	5 4
4	Refer to Figure 4-3, Servicing Block Diagram, and check for DC operating voltages and 1KHz input from counter.	1) If not correct, check connections between counter and SD 1928, then refer to counter instruction manual. 2) If correct, refer to section on troubleshooting gate and logic assembly.	
5	Test SD 1928 Signal Circuits a) Set START/STOP channel switches to ±1. b) Insert 30ns delay cable in STOP channel c) Set pulse generator for 100ns pulse width, 2.0V peak to-peak. d) Connect output of pulse generator to input of SD 1928 through Z-match transformer.	1) Counter display reads 000000.03 (SD 1038) or 00000.03 (SD 1018) 2) Counter display reads 000000.01 (SD 1038) or 00000.01 (SD 1018) 3) Counter display reads 000000.00 (SD 1038) or 00000.00 (SD 1018)	 6 7
6	Refer to Figure 4-3, Servicing Block Diagram, and check for 10MHz at input to multiplier.		
7	Refer to Figure 4-3, Servicing Block Diagram, and check START/STOP signal path.		

4.3 INPUT SWITCH ASSEMBLY

The input switch assembly consists of a T-pad attenuator, a toroid, and a four-section rotary switch. All components are mounted on the switch itself and identical assemblies are used in the start and stop channels. The schematic diagram for this assembly is shown in Figure 4-1.

The attenuator, consisting of R1 through R4, provides a 20db reduction of the input voltage in the +10 and -10 positions of S1. T1 is a toroid which provides differentiation and, in conjunction with S1, polarity selection of input signals.

Troubleshooting of this assembly consists primarily of DC resistance and continuity checks.

4.4 START-STOP SHAPER

The Start-Stop Shaper assembly consists of identical Schmitt trigger circuits connected in the Start and Stop channels. The schematic diagram for this assembly is illustrated in Figure 5-2.

Under no-signal conditions, Q1 is ON and Q2 is OFF. The circuit hysterisis is about 0.6V and will switch to the opposite state when the signal passes through -0.6V on the negative slope. The circuit will switch back at about 0V on the positive slope. The output is a nearly rectangular negative pulse with an amplitude of 5.0V peak. CR2 and CR4 provide the regulated voltage level necessary for proper triggering of the gate and logic assembly. CR1 and CR3 provide the DC interstage coupling for fast, stable switching of the Schmitt trigger circuit.

R6 and R14 provide for adjustment of the circuit triggering level with parameter variation of CR1, CR3 and transistors Q1 through Q4. Troubleshooting of this assembly consists of checking signal waveforms and transistor DC voltage levels. See the servicing block diagram, Figure 4-3, for typical waveforms and Table 4-3 for transistor DC voltage levels.

4.5 100MHz MULTIPLIER ASSEMBLY

The 100MHz multiplier consists of a crystal filter, a 10MHz amplifier, a X5 frequency multiplier and a X2 frequency multiplier. All components are mounted on a single printed-circuit board. The schematic diagram for this assembly is shown in Figure 5 - 4.

Crystal Y1 and Q3 provide filtering and amplification of the 10MHz signal from the parent counter. Q1 and Q2 are connected in the complementary-symmetry arrangement to provide adequate power for multiplication to 50MHz. Q4 functions as a X2 multiplier, providing the 100MHz counting frequency. CR1 and CR2 limit the output to the proper level for counting. C11, C12, C15 and C16 are the tuning and loading adjustments for the X5 and X2 multiplier tank circuits, respectively. These are factory set and do not normally require readjustment unless components are replaced.

Troubleshooting of this assembly consists primarily of checking signal waveforms and transistor DC voltage levels. See the servicing block diagram for typical waveforms and Table 4-3 for transistor DC voltage levels.

4.6 GATE AND LOGIC ASSEMBLY

The Gate and Logic assembly consists of the start/stop binary, the gate logic circuit and associated amplifiers. All components are mounted on a single printed-circuit board. The schematic diagram for this assembly is shown in Figure 5-5. The block and logic diagram for the J-K Master-Slave Binary is shown in Figure 5-7.

Refer to Figure 4-3, Servicing Block Diagram. Initially the Q output of the M binary is high (+3.5V) and the Q output of the S binary is low (0V). The connection from Q of M binary to J of the S binary inhibits the latter from responding to STOP input pulses until the M binary has switched its state. The high output from Q of the M binary is coupled through the OR gate and emitter-follower Q2 to the output line and prevents the 100MHz from the multiplier assembly from triggering the counter. A negative start pulse from the start/stop shaper switches the M binary, driving the output line low and allowing the 100MHz to be counted. At the same time, the S binary is enabled through the connection Q-J. A stop pulse from the start/stop shaper assembly will switch the S binary, driving the output line high and terminating the count of the 100MHz frequency. The connection from Q of the S binary to Terminal 2 of IC1 initiates the stop pulse for the counter gate. After the logic circuits of IC1 have cycled, a clear pulse (low) is generated, driving the J-K binary back to its original state.

The counter gate is enabled through the gate logic circuits of IC1 which provide the start/stop pulses for the counter gate at the output of amplifier Q6. IC1 is a quadruple, two-input positive NAND gate with the same logic levels as the J-K binary. The NAND gates of IC1 are connected to provide the following logic:

$$Y1 = \overline{\overline{A1}\,B1}\,B3$$
$$Y2 = \overline{B3}$$

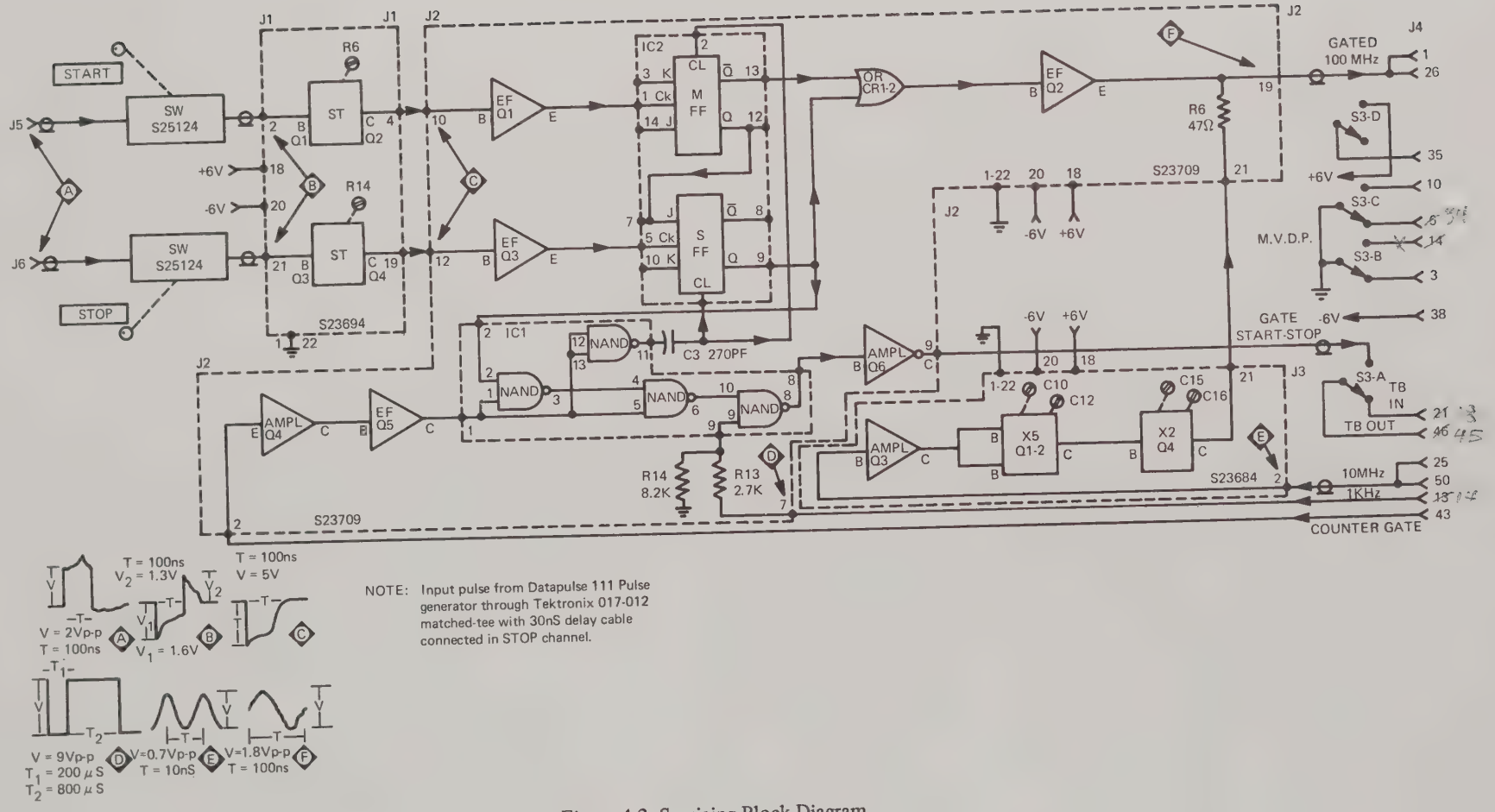
where Y1 is the counter gate start/stop output, A1 is the stop signal from the S binary, B1 is the counter gate and B3 is the 1KHz from the counter time-base generator. A second output, Y2, is the J-K binary clear pulse derived from the end of the counter gate. From the logic above and the timing diagram of Figure 4-2, it is seen that the counter gate is initiated by the 1KHz from the time-base of the counter and terminated by the stop signal from the S binary.

Although the circuit used consists entirely of NAND gates, circuit interconnection yields the logic above. Amplifier Q4 and emitter-follower Q5 provide the proper logic level drive to the gate logic circuit from the parent counter gate circuits.

Troubleshooting of this assembly consists primarily of checking signal waveforms and transistor DC voltage levels. See the Servicing Block Diagram (Figure 4-3) for typical waveforms and Table 4-3 for transistor DC voltage levels.

Assembly	Transistor	Emitter	Base	Collector	Remarks
START/STOP	Q1, Q3	-0.6V	0V	+1.5V	No-signal conditions
	Q2, Q4	-0.6V	-0.6V	+5.0V	No-signal conditions
100MHz Multiplier	Q1	+3.8V	+3.1V	0V	INT-EXT switch on
	Q2	-3.7V	-3.0V	0V	counter set to EXT
	Q3	-0.8V	0V	+6.0V	(applies to all remaining
	Q4	-2.8V	-2.1V	+6.0V	measurements)
Gate and Logic Assembly	Q1	+5.0V	+5.0V	0V	
	Q2	+0.7V	+1.4V	+6.0V	
	Q3	+5.0V	+5.0V	0V	
	Q4	+0.2V	0V	+5.0V	
	Q5	+5.0V	+5.0V	-6.0V	
	Q6	0V	+1.7V	-6.0V	

Table 4-3 Transistor DC Voltage Levels to Ground



NOTE: Input pulse from Datapulse 111 Pulse generator through Tektronix 017-012 matched-tee with 30nS delay cable connected in STOP channel.

Figure 4-3 Servicing Block Diagram

CHAPTER 5
MAINTENANCE

5.1 FACTORY SERVICE

Whenever a Systron-Donner instrument requires service, the nearest SD representative should be contacted. He can provide field service or arrange factory returns when necessary. Address all inquiries on operation or application to your nearest sales representative, or Sales Manager, Systron-Donner Corporation, 888 Galindo Street, Concord, California 94520. Specify both model and complete serial number in all correspondence.

5.2 PREVENTIVE MAINTENANCE

No special preventive maintenance procedures are required for the SD 1928. When not in use and outside the parent counter, the instrument should be stored inside an appropriate container to avoid accidental damage to exposed hardware and circuitry.

5.3 PRINTED-CIRCUIT BOARD REPAIR

To replace a part on a printed-circuit board, cut the leads of the part near the lead holes. Using a low-power (50-watt or less) soldering iron, apply heat sparingly to the cut lead. As soon as the solder melts, slip the lead from the hole and clean the hole with a toothpick. Clean the board surfaces with isoprophyl alcohol. Form the tinned leads of the replacement part and insert in the cleaned holes, trimming leads to extend 1/16-inch beyond the back surface of the board. Use only 63-37 solder with a maximum diameter of 1/16-inch. Solder the leads to the board and use a hemostat, long-nose pliers or other heat sink on the leads of all semiconductor devices and 1/4-watt resistors. Allow the soldered junction to cool before removing the heat sink. Special care should be used to insure that parts replaced on the 100MHz board conform as closely as possible to the original orientation and lead length.

5.4 PARTS LOCATION

Printed-circuit board outline drawings and assembly schematic diagrams are shown in Figures 5-1 through 5-6.

5.5 ADJUSTMENT

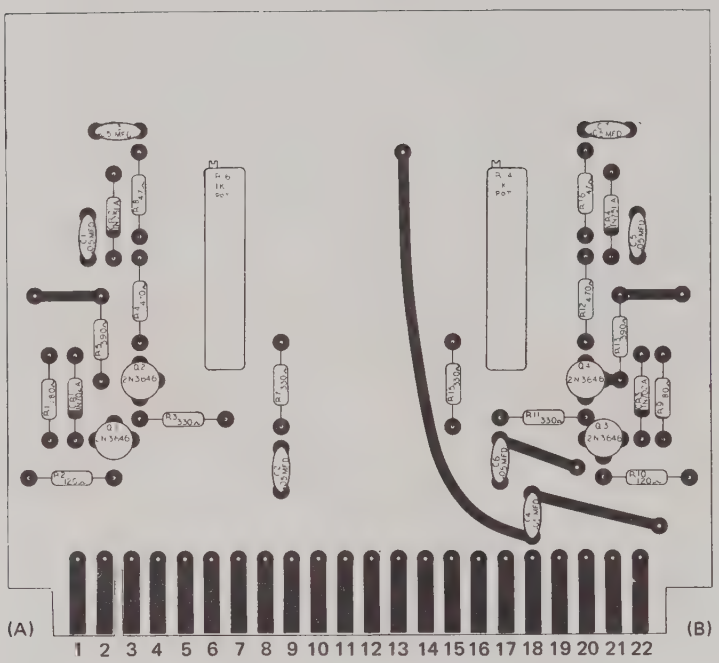
All internal adjustments are initially made at the factory and should not normally require re-adjustment unless components are replaced. Procedures for adjustment of the triggering level of the start/stop shaper and alignment of the 100MHz multiplier are given below. To permit access to internal adjustments, an extender cable must be used to allow operation of the plug-in outside the parent counter. If no cable assembly is available, the top of the counter may be temporarily removed (see Counter Instruction Manual). In either case, do not operate the equipment for extended periods in this manner as proper air flow for cooling is disrupted and may cause malfunction of the counter.

5.5.1 START-STOP SHAPER TRIGGER LEVEL ADJUSTMENT

1) Connect test set-up as given in step (5) of Table 4-2.
2) Set up the oscilloscope for dual-trace operation, 0.5V/cm on A channel, and a sweep rate of 1-microsecond/cm.
3) Connect the A-channel oscilloscope probe to the collector of Q2 in the start channel shaper, Terminal J1-4.
4) Connect the B-channel oscilloscope probe to the point where the coaxial cable from the start input jack (J5) connects to switch S1.
5) With both R6 and R14 trimpots initially set fully CCW, adjust pulse generator output for 0.8V peak as observed on the B-channel trace.
6) Adjust R6 CW until the Schmitt trigger fires as evidenced by a 100ns, 5V peak, negative pulse on the A-channel trace.
7) Connect the A-channel probe to the collector of Q2 in the stop channel circuit, Terminal J1-19; connect the B-channel probe to the point where the coaxial cable from the stop input jack (J6) connects to switch S2. Adjust the pulse generator output for 0.8V peak as observed on the B-channel trace.
8) Adjust R14 CW until the Schmitt trigger fires as evidenced by a 100ns, 5V peak, negative pulse on the B-channel trace.
9) The start/stop shaper Schmitt triggers are now properly set to trip at 0.6V input.

5.5.2 ALIGNMENT OF THE 100MHz MULTIPLIER

1) Remove the 100MHz multiplier board from its socket and replace with the PCB extender. Reinsert multiplier board into extender.
2) Set up the oscilloscope for single-channel operation; 1V/cm vertical sensitivity, 0.1 microsecond/cm.
3) Check 10MHz signal from parent counter by connecting the oscilloscope probe to Terminal J3-2. The waveform should be as shown in Figure 4-3, Servicing Block Diagram, test point E.
4) Set sweep speed on oscilloscope at 0.5-microseconds/cm and connect the probe to the base of Q4.
5) Adjust C10 and C12 alternately until maximum amplitude of the 50MHz signal is obtained.
6) Connect the probe to J3-21 and adjust C15 and C16 until maximum amplitude of the 100MHz signal is obtained.
7) Repeat steps (5) and (6) until no further significant change is noted. The 100MHz signal amplitude should be approximately 0.7V peak-to-peak.
8) Remove the extender board and replace the multiplier board in its socket. Recheck the 100MHz signal at J3-21. If the signal level is below about 0.7V peak-to-peak, repeat steps (6) and (7) until the proper level is achieved.
9) Check for a proper count by performing step (5) of Table 4-2.



NOTES
1. All resistors ¼ watt unless otherwise noted.
2. All capacitances in MFD.

Figure 5-1 Outline Drawing, Start-Stop Shaper PCB

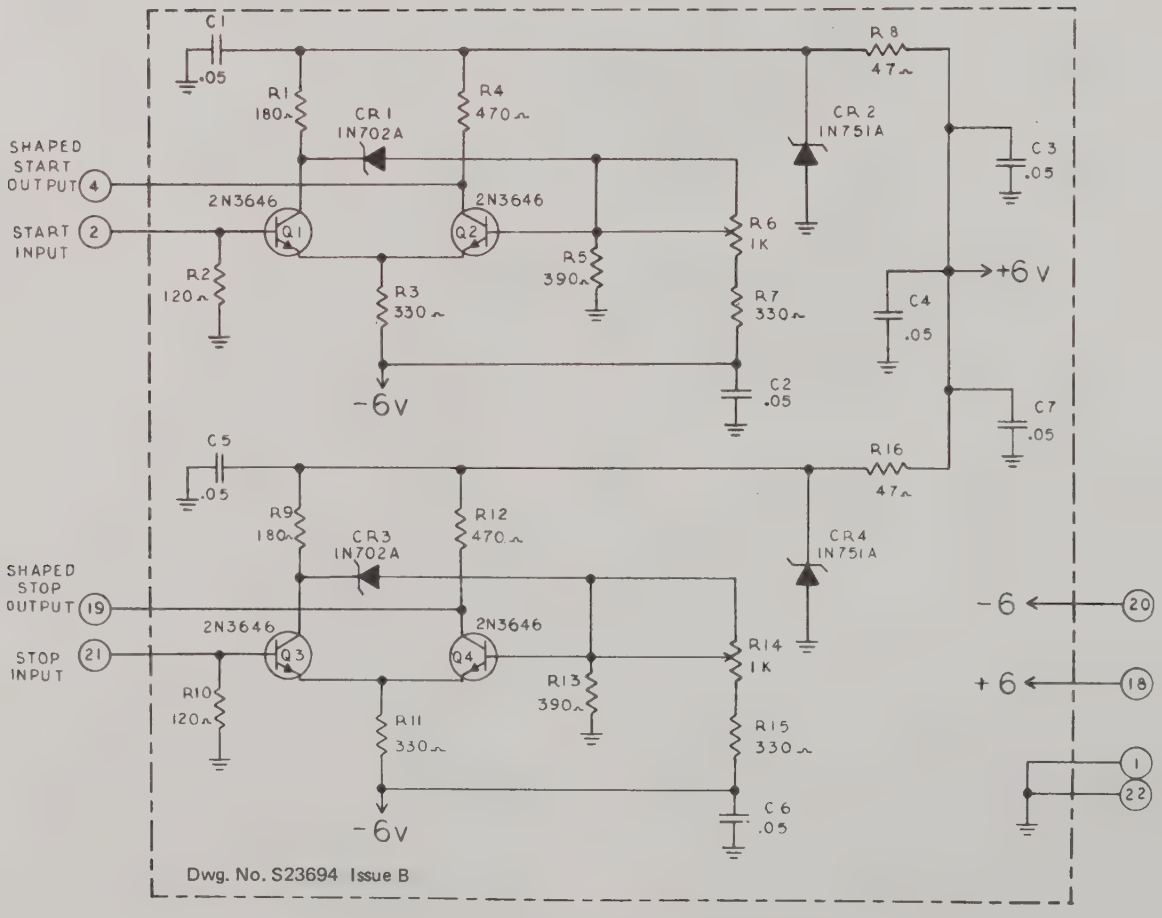
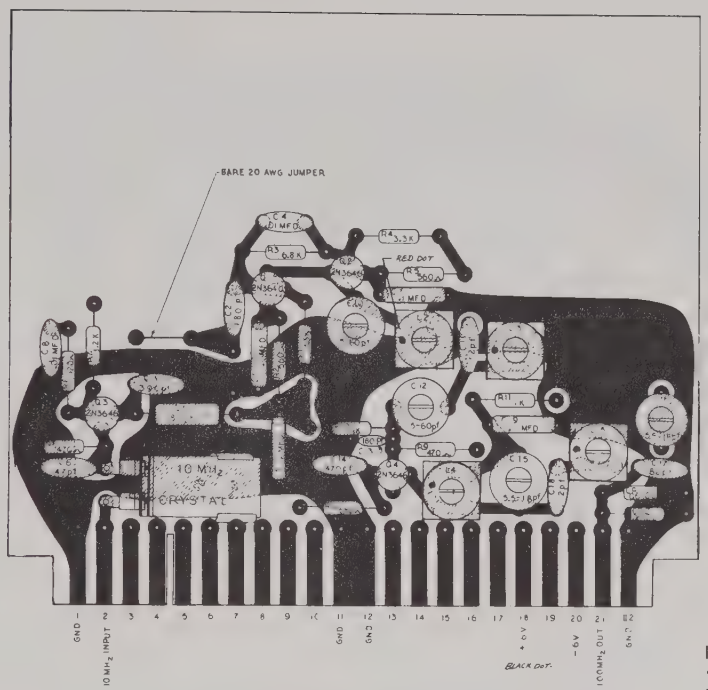
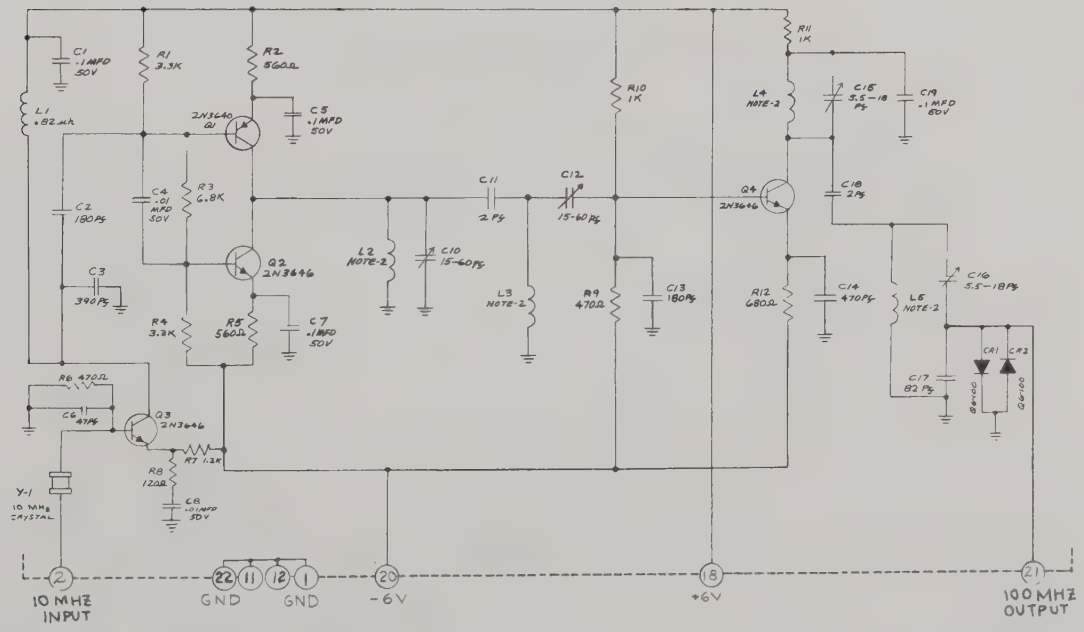


Figure 5-2 Schematic Diagram, Start-Stop Shaper



NOTES
1. All resistors ¼ watt.
2. All capacitance in MFD unless otherwise noted.

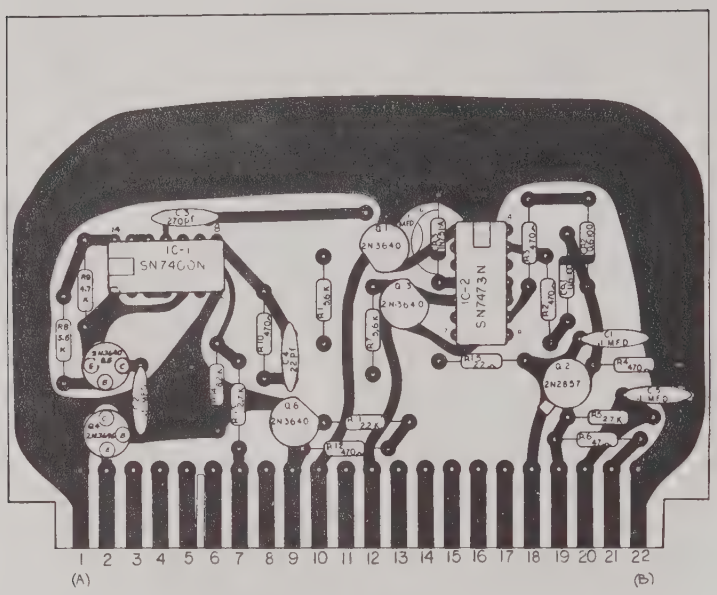
Figure 5-3 Outline Drawing, 100MHz Multiplier PCB



NOTES
Unless Otherwise Specified
On DWG
1. All resistors are 5% - ¼ watt carbon comp.
2. Inductors L2-L3-L4 & L5 are custom. Ref. P/LS23683.

Dwg. No. S23684 Issue B

Figure 5-4 Schematic Diagram, 100MHz Multiplier



NOTES

All resistors ¼ watt.
All capacitance in MFD.

Figure 5-5 Outline Drawing, Gate and Logic PCB

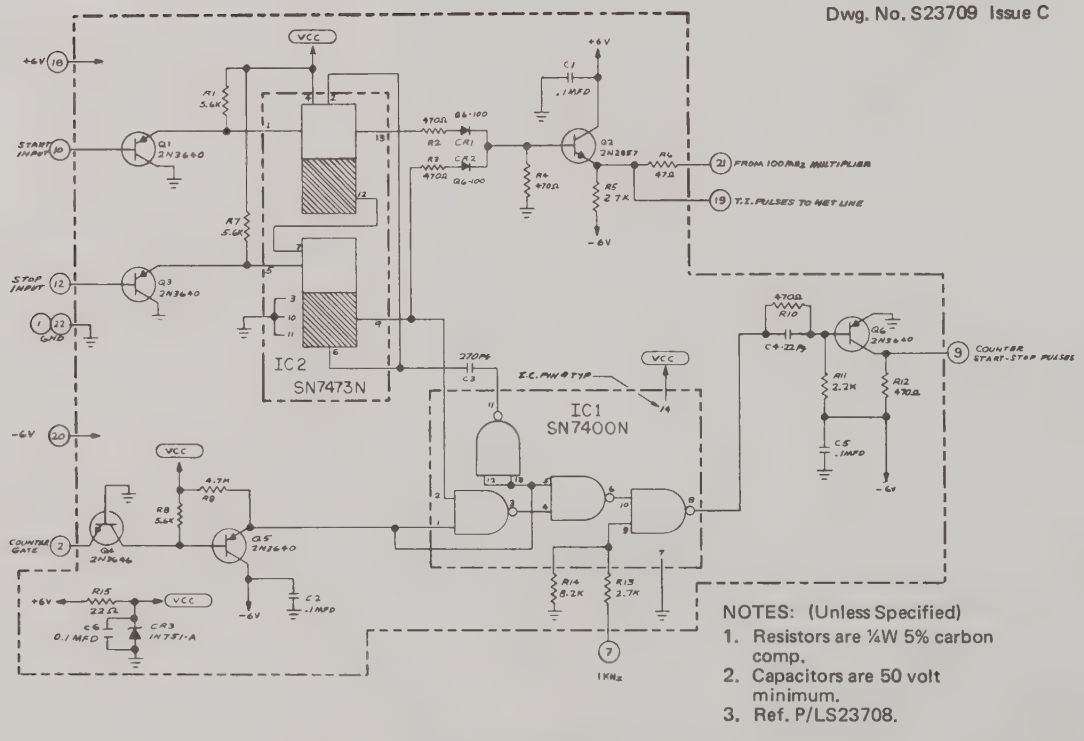
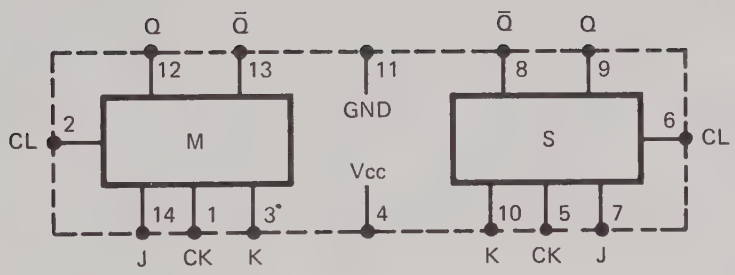


Figure 5-6 Schematic Diagram, Gate and Logic



t_n		t_n+1
J	K	Q
0	0	Qn
0	1	0
1	0	1
1	1	$\bar{Q}$n

Figure 5-7 Block and Logic Diagram, J-K Flip-Flop

CHAPTER 6
PARTS LIST

Ass'y	Ref. Desig.	Description	S-D Part Number
S25124		**INPUT SWITCH ASS'Y**	
	C1	Capacitor, 0.002 μF, disc ceramic	---
	R1	Resistor, comp., 39 ohms, 1/2W, 5%	R0724
	R2	Resistor, comp., 39 ohms, 1/4W, 5%	R1552
	R3	Resistor, comp., 22 ohms, 1/2W, 5%	R1436
	R4	Same as R3	
	R5	Resistor, comp., 51 ohms, 1/2W, 5%	R0427
	S1	Switch, rotary, 4-sect., 4 position	OAK399-225A
	T1	Transformer, toroid	S25125
S23694		**START-STOP SHAPER ASS'Y**	
	C1	Capacitor, 0.05 μF, 50V	C0708
	C2	Same as C1	
	C3	Same as C1	
	C4	Same as C1	
	C5	Same as C1	
	C6	Same as C1	
	C7	Same as C1	
	CR1	Diode, semiconductor, zener, 1N702A	
	CR2	Diode, semiconductor, zener, 1N751A	CR0095
	CR3	Same as CR1	
	CR4	Same as CR2	
	Q1	Transistor, 2N3646	Q0218
	Q2	Same as Q1	
	Q3	Same as Q1	
	Q4	Same as Q1	
	R1	Resistor, comp., 180 ohms 1/4W, 5%	R1233
	R2	Resistor, comp., 120 ohms 1/4W, 5%	R1461
	R3	Resistor, comp., 330 ohms 1/4W, 5%	R0662
	R4	Resistor, comp., 470 ohms 1/4W, 5%	R1044
	R5	Resistor, comp., 390 ohms 1/4W, 5%	R0880
	R6	Resistor, potentiometer, 1000 ohms, 1/2W, ±10%	R1288
	R7	Same as R3	
	R8	Resistor, comp., 47 ohms 1/4W, 5%	R0743
	R9	Same as R1	
	R10	Same as R2	
	R11	Same as R3	
	R12	Same as R4	
	R13	Same as R5	
	R14	Same as R6	
	R15	Same as R7	
	R16	Same as R8	
S23683		**100MHz MULTIPLIER ASS'Y**	
	C1	Capacitor, 0.1 F, 50V	C0881
	C2	Capacitor, 180pF, dip mica	C0643
	C3	Capacitor, 390pF, dip mica	C0541
	C4	Capacitor, 0.01 μF, 50V ceramic disc	C0562
	C5	Same as C1	
	C6	Capacitor, 47pF, dip mica	C0553
	C7	Same as C1	
	C8	Same as C4	
	C9	Not Used	
	C10	Capacitor, 15-60pF Variable	Erie 538-011 P3PO 112R
	C11	Capacitor, 2pF, ceramic disc	C0261
	C12	Same as C10	
	C13	Same as C2	
	C14	Capacitor, 470pF	C0542
	C15	Capacitor, 5.5-18pF variable	C0712
	C16	Same as C15	
	C17	Capacitor, 82pF, dip mica	C0535
	C18	Same as C11	
	C19	Same as C1	
	L1	Inductor, 0.82 μH	L0059
	L2	Inductor Ass'y	S25103
	L3	Same as L2	
	L4	Inductor Ass'y	S25106
	L5	Same as L4	
	Q1	Transistor, 2N3640	Q0178
	Q2	Transistor, 2N3646	Q0218
	Q3	Same as Q2	
	Q4	Same as Q2	
	R1	Resistor, comp., 3.3k ohms 1/4W, 5%	R0742
	R2	Resistor, comp., 560 ohms 1/4W, 5%	R0819
	R3	Resistor, comp., 6.8k ohms 1/4W, 5%	R0696
	R4	Same as R1	
	R5	Same as R2	
	R6	Resistor, comp., 470 ohms 1/4W, 5%	R1044
	R7	Resistor, comp., 1.2k ohms 1/4W, 5%	R0809
	R8	Resistor, comp., 120 ohms 1/4W, 5%	R1461
	R9	Same as R6	
	R10	Resistor, comp., 1k ohms 1/4W, 5%	R0765
	R11	Same as R10	
	R12	Resistor, comp., 680 ohms 1/4W, 5%	R1234
	Y1	Crystal, 10MHz	Y0022
S23708		**GATE AND LOGIC ASS'Y**	
	C1	Capacitor, 0.1 μF, 50V	C0881
	C2	Same as C1	
	C3	Capacitor, 270pF	C0539
	C4	Capacitor, 22pF	C0529
	C5	Same as C1	
	C6	Capacitor, 0.1 μF, 10V	C0661
	CR1	Diode, semiconductor, Q6-100	CR0194
	CR2	Same as CR1	
	CR3	Diode, semiconductor zener, 1N751A	---
	IC1	Integrated Circuit, quad 2-input NAND gate, TI SN7400N	19705
	IC2	Integrated Circuit, J-K Flip-Flop, TI SN7473N	19709
	Q1	Transistor, 2N3640	Q0178
	Q2	Transistor, 2N2857	---
	Q3	Same as Q1	
	Q4	Transistor, 2N3646	Q0218
	Q5	Same as Q1	
	Q6	Same as Q1	
	R1	Resistor, comp., 5.6k ohms 1/4W, 5%	R0821
	R2	Resistor, comp., 470 ohms 1/4W, 5%	R1044
	R3	Same as R2	
	R4	Same as R2	
	R5	Resistor, comp., 2.7k ohms 1/4W, 5%	R0937
	R6	Resistor, comp., 47 ohms 1/4W, 5%	R0743
	R7	Same as R1	
	R8	Same as R1	
	R9	Resistor, comp., 4.7k ohms 1/4W, 5%	R0892
	R10	Same as R2	
	R11	Resistor, comp., 2.2k ohms 1/4W, 5%	R0721
	R12	Same as R2	
	R13	Resistor, comp., 2.7k ohms 1/4W, 5%	R0937
	R14	Resistor, comp., 8.2k ohms 1/4W, 5%	R0883

SYSTRON DONNER
CORPORATION

WARRANTY

Systron-Donner instruments are warranted during a period of one year from date of shipment to original purchaser to be free from defects in material and workmanship. This warranty does not apply to vacuum tubes, except as they are warranted by tube manufacturers. The liability of Seller under this warranty is limited to replacing or repairing any instrument or component thereof which is returned by Buyer at his expense during such period and which has not been subjected to misuse, neglect, improper installations, repair, alteration, or accident. Seller shall have the right of final determination as to the existence and cause of a defect. In no event shall Seller be liable for collateral or consequential damages. This warranty is in lieu of any other warranty, express, implied or statutory, and no agreement extending or modifying it will be binding upon Seller unless in writing and signed by a duly authorized officer.

RECEIVING INSPECTION

Every Systron Donner instrument is carefully inspected and is in perfect working order at the time of shipment. Each instrument should be checked as soon as received. If the unit is damaged in any way or fails to operate, a claim should immediately be filed with the transportation company.

REPAIRS

Whenever a Systron-Donner instrument requires service, the nearest Systron-Donner representative should be contacted; all representatives will provide immediate service or arrange factory returns when necessary.

Please specify both model and serial number in all correspondence concerning Systron-Donner instruments. Address all inquiries on operation or applications to your nearest sales representative or Sales Manager, Instruments, Systron-Donner Corporation, 888 Galindo Street, Concord, California.

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